

CHAPTER EIGHT

Rain-Fed Farming and Settlement Aggregation

Reflections from Chihuahua, Mexico

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The ancient farming societies of the southwestern United States confronted a fundamental and shared challenge: the precipitation regime of the region seldom provided sufficient moisture during the growing season to support the production of maize and other cultigens. To ensure adequate moisture for their crops, the members of these societies likely adopted a mix of cultivation techniques, which Mabry (2005:124–130) organizes into six categories:

1. Rain-fed farming: Fields were located in areas with adequate and properly timed rainfall.¹
2. Dry farming: Fields were located in areas with moisture-retaining soils.
3. Water-table farming: Fields were located in areas with high water tables.
4. Flood farming: Fields were located in naturally flooding areas.

5. Runoff farming: Surface gradients were modified to slow runoff in field locations, and runoff or seasonal streamflows were diverted to fields.
6. Irrigated farming: Perennial flows from rivers, streams, or springs were diverted to fields.

Highly localized variations in topography, hydrology, and precipitation would have affected the techniques suitable for any given locality, with rain-fed farming assumed to have been limited to higher elevations, which tend to receive more rainfall during the maize growing season (Mabry 2005:124). However, at higher elevations temperature parameters, such as the number of frost-free days and the total heat available during the growing season, are more important (see Adams, Chapter 1, this volume). In their study of temperature and precipitation of the southwestern Colorado region, Adams and Peterson (1999:26) report that, during the historic period, rain-fed farming of maize and beans had been most successful between 1,920 m (6,300 ft) and 2,164 m (7,100 ft), concluding that ancient Southwest farmers cultivating lands lower than 6,000 ft “would have had to manage runoff or irrigate to supplement direct rainfall.”

The region of North America closest to the Southwest where rain-fed maize farming is possible begins only about 200 km south of the U.S. border, in northwestern Chihuahua, Mexico, extending from there through the remainder of the continent. The prehispanic human occupation of the northern portion of this region, specifically central and southern Chihuahua, has long puzzled archaeologists. Despite being flanked by aggregated Casas Grandes Puebloan settlements to the north and aggregated Mesoamerican settlements of Guadiana Chalchihuites affiliation to the south, almost no evidence of any aggregated settlements has been encountered in the 300-km stretch separating these two traditions (Figure 8.1).

The expectation that aggregated settlements should be present but are largely absent raises a series of key issues that are not well understood. We address these lacunae via a hypothesis that leads to a number of questions that future research should address. Our essay focuses on the dynamics of aggregation in relation to precipitation, and we suggest that further research in this region offers the potential of gaining new insights into the relationships between agricultural strategies and aggregation or lack thereof. Our work adds to a substantial body of research that addresses aggregation and its absence as the outcome of complex interactions of varying suites of ecological, economic, political, social, and cultural variables (Adler 1994; Anschuetz et al. 2001; Cordell 1994; Cordell et al. 1994; Cordell and Plog 1979; Crown and Kohler 1994; Kintigh 1994; Kohler 2004a, 2004b; Kohler et al. 2004; LeBlanc 1999; Lipe 1994, 2010; Longacre 1966; Winterhalder and Kennett 2006).

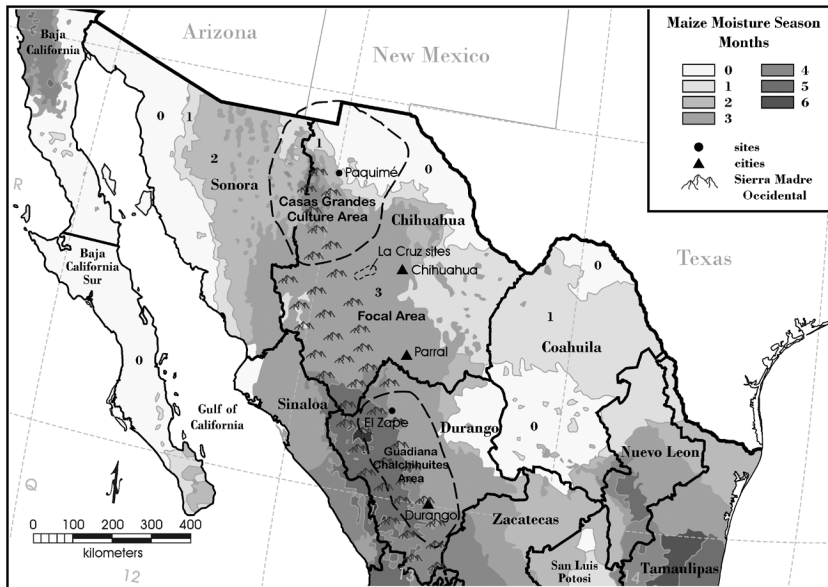


FIGURE 8.1. Focal area is indicated and maize moisture months are shown in gray tones.

Archaeological research undertaken in central and southern Chihuahua between the 1920s and 2009 shows that the prehispanic populations who lived here followed a mixed farming and foraging subsistence strategy via a dispersed rancheria settlement strategy in which nuclear or extended households built their growing-season residences adjacent to their fields. During our research between 2002 and 2009, we developed the hypothesis that environmental traits conducive to rain-fed maize farming contributed significantly to the emergence and persistence of this dispersed subsistence-settlement strategy in our focus area. To evaluate this hypothesis, we first determined the areas in Chihuahua and adjacent portions of the southwestern United States and northern Mexico where the conditions required for rain-fed farming were present or absent. We then compared the distribution of these areas to the known distributions of aggregated and nonaggregated settlements, discovering that the zone where a dispersed settlement strategy appears to have prevailed corresponds to the area where the minimal conditions for rain-fed maize farming existed. In this chapter, we present the results of this study and offer our perspectives on why the possibility for rain-fed farming might have been a factor in the settlement and subsistence strategies of the ancient inhabitants of central and southern Chihuahua. We conclude with a discussion of what we need

to know to further our understanding of rain-fed farming and settlement in the region and why this topic is important for future research.

The Focal Area

Rain-fed farming is possible in most of the western half of the state of Chihuahua in the zone where the moisture required for maize farming is available for at least three consecutive months during the growing season (see Figure 8.1 and the following section). In this chapter, our focus is on the portion of this zone located east of the Sierra Tarahumara.² Extending for about 600 km from just south of the Casas Grandes center of Paquimé to the Chihuahua-Durango border, this area of mixed grasslands and woodlands is situated at 1,500–2,100 m in foothill, plains, and basin-and-range country (Pennington 1963:35–38, Map 4). The Río Conchos, which flows into the Río Grande (Río Bravo), drains the portions of the zone that lie east of the Continental Divide, while rivers on the western side empty into the Gulf of California (Figure 8.2).

Modern mean annual precipitation in the focus area is in the 330–500 mm range, increasing westward and southward to reach 700 mm at the higher elevations of the Sierra Tarahumara. Rainfall is dominated by the North American Monsoon, which usually begins in late June or early July and ends by late September, bringing 60–70 percent of the annual precipitation (García et al. 1973a, 1973b). Located on the lee side of the Sierra Madre Occidental, the focus area receives relatively small amounts of winter moisture from Pacific storms. Nonetheless, winter moisture is an important contributor to the soil moisture required for seed germination because planting takes place during the spring months, the driest of the year.

Between 2002 and 2009, we completed an archaeological project in central and southern Chihuahua involving reconnaissance, systematic survey, and test excavations focusing on locations shown in Figure 8.2. No major aggregated settlements were located there, including during the intervals when the Chalchihuites (A.D. 600–1400) and Casas Grandes cultures (A.D. 700–1450) were flourishing. In fact, the only evidence of aggregated prehispanic settlements that we encountered in our project area are 17 terraced hill (*cerros de trincheras*) sites (see below) and a few additional sites with small clusters of houses or house blocks in far southern Chihuahua.

Rain-Fed Farming Potential and the Maize Moisture Season

A key factor affecting where rain-fed maize farming is possible is the duration of what we call the “maize moisture season,” that is, the number of

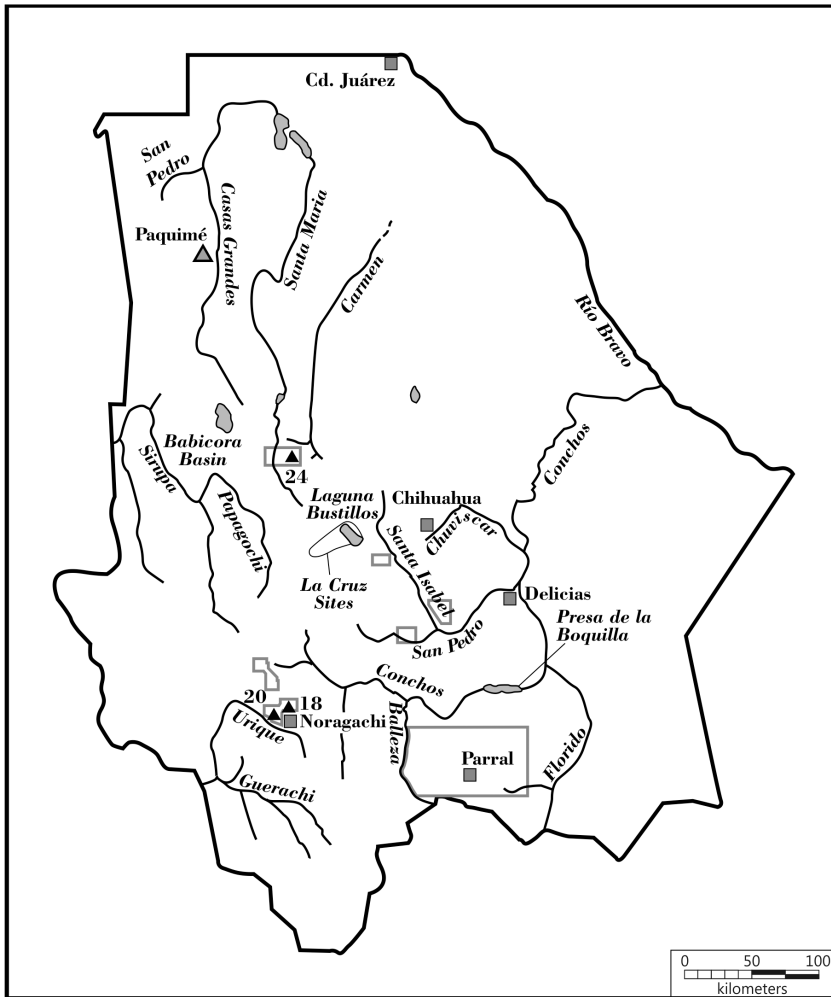


FIGURE 8.2. Polygons represent our archaeological study areas and contain the sites listed in Tables 8.1 and 8.2. Sites 18, 20, and 24 are identified by black triangles, while all other sites are on Figure 8.5.

consecutive months during the frost-free period of the year when the soil moisture level sufficient for maize to grow successfully is available.³ Our data come from the *Maize Atlas*, whose authors refer to the maize moisture season as the “trigger season” (Hodson et al. 2002). Using modern mean monthly climatological data from the same source, we have plotted the maize moisture season for northern Mexico (Figure 8.1). Throughout the area of our study, the maize moisture season is three months long,

adequate for rain-fed farming. In adjacent areas to the south, the maize moisture seasons range from three to five months. The three-month maize moisture season continues northward up to the vicinity of Paquimé, where it declines to one to two months per year. In northernmost Chihuahua, like much of the southwestern United States, no month during the year has sufficient soil moisture for rain-fed maize growth.

Most of the paleoclimatological data available for Chihuahua during the prehispanic period are based on analyses of lacustrine deposits and are presented on the scale of centuries to millennia. Although they lack the temporal resolution of tree-ring data, paleoclimatological data indicate that modern climate conditions in Chihuahua were established around 4,000 years ago. The late Holocene was characterized by multiple fluctuations in effective moisture (Metcalf 2006; Ortega-Ramírez et al. 1998). Periods of increased effective moisture occurred around 4000–3000 B.P., 1500 B.P., and 500 B.P. In fact, effective moisture was greater throughout much of the past two millennia than it is in modern-day Chihuahua (Metcalf 2006; cf. Metcalf et al. 1997; Nordt 2003; Ortega-Ramírez et al. 1998:1177; Urrutia-Fucugauchi et al. 1997).

The calculations of maize moisture seasons in Chihuahua and adjacent areas do not take into account the recurrent droughts that occur in the region. Periodic droughts during the maize growing season are identified as a significant (but not sole) factor in models designed to account for shifts between aggregated and dispersed settlement patterns documented in the archaeological record of the Southwest and Great Basin (Hill et al. 1996; cf. Kohler et al. 2004:301; Leonard and Reed 1993; Madsen and Simms 1998:313–320). Short-term droughts have yet to be clearly defined with local dendrochronological sequences for prehispanic Chihuahua. However, reconstructed Palmer Drought Severity Indices (PDSI) using tree-ring data from across northern Mexico indicate that a drought occurred in the late A.D. 1300s, while the A.D. 1559–1582 megadrought impacted much of Mexico, the Southwest, and Canada (Seager et al. 2009). Díaz and colleagues (2002) provide an analysis of tree-ring data from Chihuahua over the span of three and a half centuries (1647–1992), a series that begins about a century following initial Spanish colonization in our focus area. They concluded that winter-spring droughts lasting five to ten years are part of the climatic variability in Chihuahua and that precipitation patterns in Chihuahua partially correlate with the El Niño–Southern Oscillation (ENSO) (cf. Endfield 2007:11). They also identified at least four droughts that lasted more than ten years during the same time period.

Their study complements records of droughts in the Conchos Basin that are preserved in Spanish colonial period documents (Endfield 2007, 2008; Endfield and Fernández-Tejedo 2006). According to these records,

severe droughts occurred at least eight times during the eighteenth century, many correlating with epidemics, uprisings, and severe economic disruptions. More recent data from Conchos Basin weather stations for the period 1934–1998 show the same pattern. Kim and colleagues (2002) determined that droughts were frequent and that the decade-long drought of the 1990s was, in terms of the PDSI, extreme in its severity and scale, impacting 70 percent of the area. They estimate that droughts of this magnitude occur once every century. Given the consistency of these patterns and their apparent links to the North American Monsoon and ENSO events, such droughts presumably extended back at least several millennia (e.g., Metcalfe 2006).

Modern Rain-Fed Maize Farming in the Three-Month Maize Moisture Zone

To evaluate whether a three-month maize moisture season is sufficient to successfully produce a maize crop, we analyzed modern grain maize agricultural data. Our data were collected by Mexico's National Institute for Statistics, Geography, and Information Technology (INEGI) and obtained from Yale University Library (2004). These data provide details on the number of hectares planted for maize grain production under irrigated vs. rain-fed conditions for most *municipios* throughout the country. Data from the 1993 agricultural cycle form the most complete data set available for Chihuahua and Durango. The proportion of hectares planted in rain-fed plots relative to all maize fields (rain-fed plus irrigated) is an indicator of the relative investment in rain-fed farming strategies at the *municipio* (equivalent to the U.S. county) level. These proportions are displayed on the map in Figure 8.3 as circled values, and the gray-tone isopleths show number of maize moisture months. The 22 *municipios* in our focus area are outlined in Figure 8.3. All are located east of the Sierra Tarahumara and have a three-month moisture season.

Most *municipios* with a three-month maize moisture season have more than half of their maize fields in rain-fed plots (Figure 8.3). Fourteen of these (63 percent) planted at least 50 percent of their maize hectares in rain-fed fields, and of these, eight relied on rain-fed farming for 90–100 percent of their maize. The eight *municipios* that produced less than 50 percent of their maize crop through rain-fed farming are all centers of large-scale, mechanized agriculture. This pattern continues in eastern Durango, also with a three-month maize moisture season, where rain-fed maize production varies from 40 to 100 percent.

Maize moisture months plotted against proportion of hectares planted in rain-fed plots for 82 *municipios* throughout Chihuahua and Durango

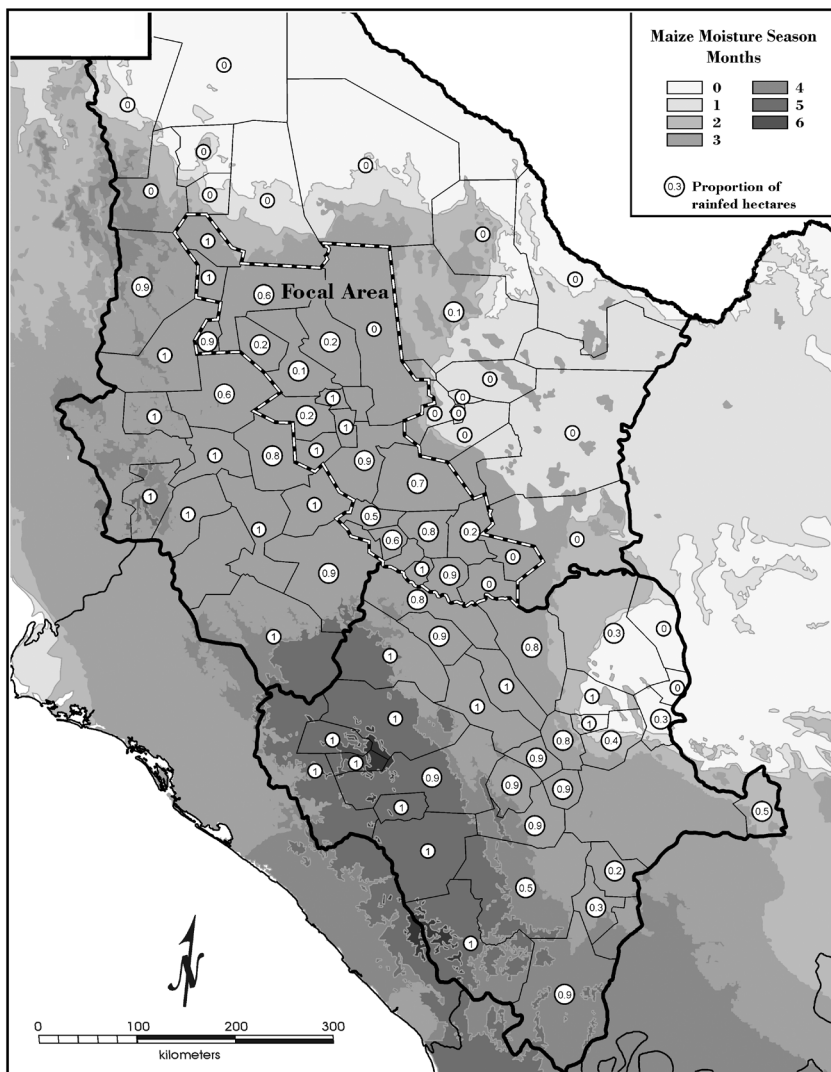


FIGURE 8.3. Maize moisture months are shown with gray tones, and the proportion of maize hectares planted in rain-fed fields for the *municipios* of Chihuahua and Durango are provided inside the circles. No data were available for some *municipios*. The boundaries of the 22 *municipios* in our focal area are outlined; these *municipios* all have a three-month maize moisture season and lie east of the Sierra Tarahumara.

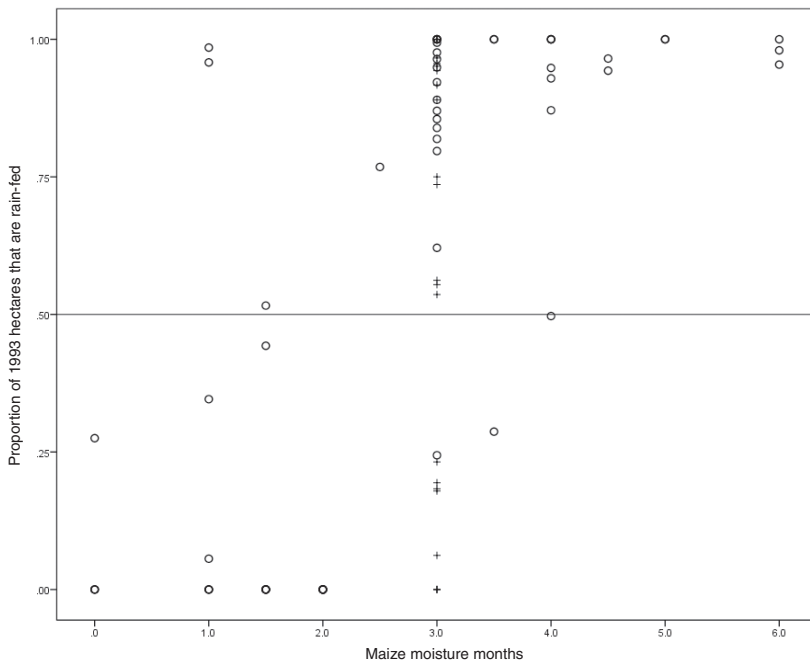


FIGURE 8.4. Scatterplot shows maize moisture months and the proportion of all maize hectares planted in rain-fed fields for 82 *municipios* in Durango and Chihuahua. Plus markers indicate the 22 *municipios* that make up our focal area, while circles are all other *municipios*. *Municipios* that contain more than one value for maize moisture months were handled in the following manner: If at least 75 percent of the *municipio* was one value, then that value was used; otherwise, an average of the maximum and minimum maize moisture months in the *municipio* was used. Maize moisture months positively correlate with the proportion of rain-fed hectares.

demonstrate that the length of the maize moisture season is a useful index of the potential for rain-fed maize farming. Only 15.4 percent (4 out of 26) of *municipios* with less than a three-month maize moisture season plant one-half or more of their maize crop in rain-fed fields. Similar to the pattern in our focus area, a three-month season provides sufficient moisture so that 76.9 percent (30 out of 39) of *municipios* in Chihuahua and Durango have one-half or more of their fields in rain-fed conditions. It jumps to 88.2 percent (15 out of 17) for *municipios* with a three- to six-month season. If only those *municipios* with four or more maize moisture months are considered, 100 percent have one-half or

more of their fields in rain-fed conditions, including those that transition from three- to four- to five-month maize moisture season zones. In contrast, all 1993 maize-planting data included in the INEGI dataset for the *municipio* of Nuevo Casas Grandes, where Paquimé is located, took place on irrigated fields. In summary, these data confirm that a three-month maize moisture season is definitely adequate for successful maize production and show that the maize moisture season is a useful index of the potential for rain-fed maize farming.

Archaeological Research and Settlement Types in Central and Southern Chihuahua

By the late 1930s, archaeologists understood that unequivocally Mesoamerican sites extended north to the Zape district of northwestern Durango and that Casas Grandes culture extended south into the Babícora district of central Chihuahua (see Figures 8.1 and 8.2) (Brand 1939; Hewett 1993; Mason 1971; Phillips 1989). Occasional fieldwork in the intervening 300 km gradually revealed that there were scattered groups of hunter-gatherers and small-scale farmers in this region, but nothing remotely approaching substantial population aggregations (Brooks 1971; Guevara Sánchez 1992; Kelley 1956; Marrs 1949).

In 1989 Jane Kelley and colleagues initiated an archaeological project directed toward defining the southern boundary of the Casas Grandes cultural region in central Chihuahua and the nature of settlements in the Bustillos Basin and adjacent areas in central Chihuahua (Kelley et al. 1999; Larkin et al. 2004; MacWilliams 2001; MacWilliams and Kelley 2004; Stewart et al. 2004). Their research demonstrated that the southern limit of Viejo and Medio period Casas Grandes sites was in the upper reaches of the Río Santa María. Just to the south of these Casas Grandes sites, around Laguna Bustillos, they identified a complex that they labeled “La Cruz” Ceramic period sites.

Excavation of several of these sites indicated they are very small settlements that date, for the most part, between A.D. 800 and 1250, making them contemporary with Casas Grandes Viejo period sites. The sites contain remains of but a few scattered jacals and shallow round pithouses with low artifact densities. The ceramics include tall jars that are mostly plainwares, with a few red-on-brown and textured sherds (MacWilliams and Kelley 2004). Two-hand manos and compatible metates are consistent with maize processing, and the chipped stone reflects an expedient technology based on local material. The sites yielded abundant samples of charred maize and beans, although the frequency of maize in flotation samples was well below that of Medio and Viejo period sites in the region

(Adams 2013; MacWilliams and Kelley 2004). A wide array of utilized wild food plants includes pinyon, walnut, juniper, and oak (Adams 2013). Animals exploited include rodents, lagomorphs, and cervids (MacWilliams 2001; MacWilliams and Kelley 2004).

La Cruz sites exemplify a rancheria pattern of dispersed houses and residential mobility associated with a mixed foraging-farming subsistence strategy. These sites tend to be located on terraces above streams that drain into closed-basin lakes, suggesting a rain-fed farming technique, and on lower alluvial fans in the basins, which could indicate either rain-fed or water-table farming. After A.D. 1200, during a period of declining levels of effective moisture that has continued to the present (Ortega-Ramírez et al. 1998:1177), the region was virtually abandoned. The only evidence of later occupation is Cerro del Apache (see below), a small terraced hill site postdating A.D. 1200 (MacWilliams and Kelley 2004:262).

The distribution of the La Cruz complex marks the northern limit of the area where no evidence of aggregated settlements has been located, and the complex's southern boundary corresponds to the northern boundary of our 2002–2009 research project area. Our data indicate that southern Chihuahua was inhabited throughout the Holocene, with sites found in diverse settings, including hilltops, alluvial terraces, bajadas, valley floors, and rockshelters. Projectile point data indicate that by the middle to late Archaic periods people were using most of these settings (MacWilliams et al. 2006; MacWilliams et al. 2009).

During our 2002–2009 research, we focused our reconnaissance and surveying on the settings that we considered most favorable for ancient agriculture, particularly along alluvial terraces of primary and secondary drainages. We documented 93 sites (Table 8.1)—virtually all that we encountered—and completed test excavations of 17 of them to assess age, condition, stratigraphy, and research potential and to collect samples for

TABLE 8.1. Site Types Recorded in Central and Southern Chihuahua.

Site Type	Count
Terraced hilltop sites	17
Habitation sites (structures present with sherds and lithics)	7
Rockshelters	35
Sherds and lithics only	7
Lithics only	22
Rock art	2
Other	1
Historic sites	2
Total	93

radiocarbon dating.⁴ The areas within which the sites were found are shown as polygons on Figure 8.2.

Twenty-four sites contain Ceramic period residential components, as indicated by the presence of house foundations. These include 17 terraced hill sites and seven other habitation sites (Table 8.1). We also identified rockshelters and small sherd and lithic scatters that may have served as Ceramic period residential locations but did not have evident dwellings. None were candidates for aggregation sites.

Terraced hill sites, or *cerros de trincheras*, are the most common Ceramic period site type we encountered (Table 8.2 and Figure 8.5). Seven of these sites have radiocarbon dates, and six sites have dates that fall into the interval of A.D. 500–900, which probably reflects the major period of use for terraced hill sites in southern Chihuahua (MacWilliams et al. 2006; MacWilliams et al. 2009). These sites have 15–2,100 m of terrace walls built with stacked rocks and have 0–53 rock circles (median = 5), presumably representing structures built on top. At least three sites contain open areas that may be public spaces. Assemblages are variable and include low densities of brown to buff plainware, with infrequent redware. We estimate maximum sherd counts in the hundreds on some sites. The only metate fragments seen are basin and slab varieties. A number of these sites have Archaic dart points and arrow points (MacWilliams et al. 2009).

The largest of the terraced hill sites is Cerro Corrales, located about 70 km east of Parral on the Río Florido. We obtained a radiocarbon date of cal A.D. 670–880 (2-sigma), as well as a historic period radiocarbon date.⁵ This site contains 53 rock rings that are presumably structures and 2,100 m of constructed terrace walls. The second largest of the terraced hill sites is Cerro La Ciénega (A47-18), an undated site located about 35 km north of Parral. This site, covering 5 ha, has about 80 features, including 925 m of walls and 21 separate structure foundations, circular and rectangular in shape, that are clustered at the northern end of the site. These sites represent the largest two settlement aggregations found in central and southern Chihuahua, although they are well below the largest well-known terraced hill sites in the Río Casas Grandes Valley, the Tucson Basin, and Río Magdalena, Sonora (Fish et al. 2007).

The seven other habitation sites also tend to be found on elevated locations and contain 1–15 stone foundations, with a median of three (Table 8.2 and Figure 8.5). Four of these warrant brief commentary. The site with 15 house foundations (A56-01) is situated on a mesa above the Río Balleza, 2 km south of the town of Balleza. The site with the next largest number of structures (A57-11) is located about 25 km west-northwest of Parral on a ridge above a tributary of the Río Conchos. It includes the remains of six structures, some associated with ceramics. The structures

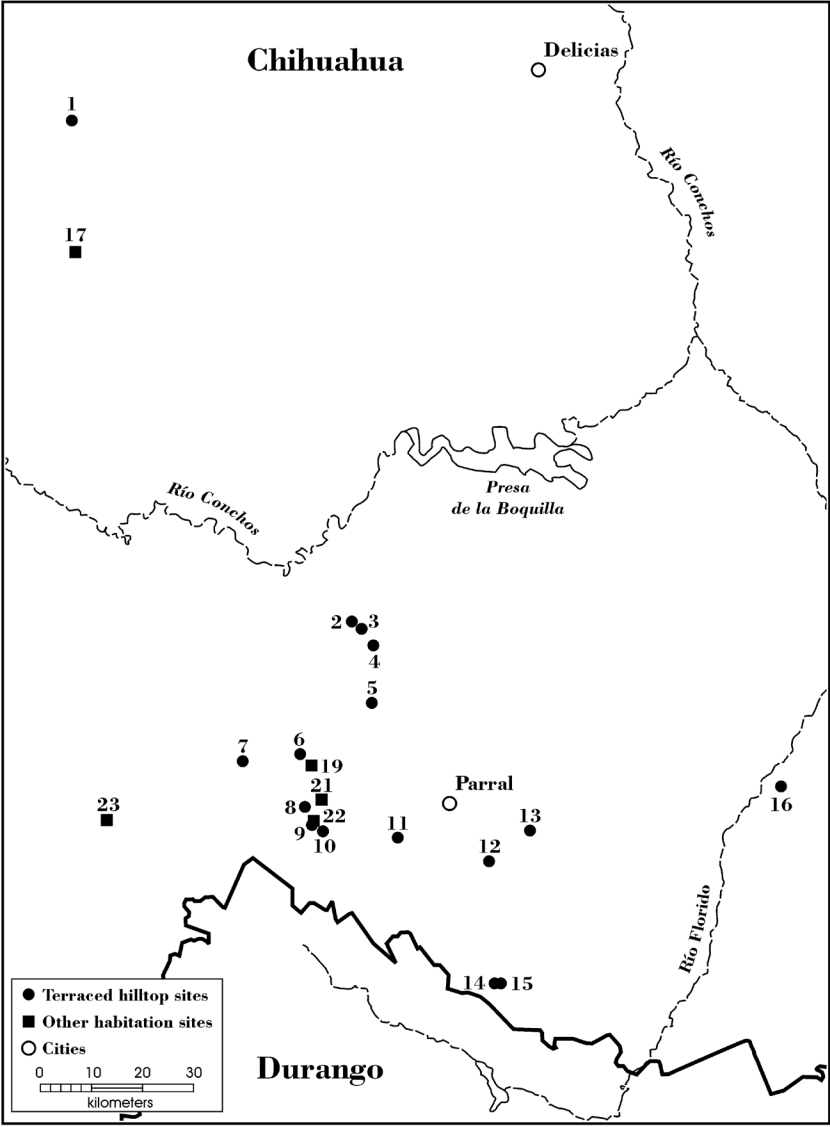


FIGURE 8.5. Locations of terraced hilltop sites (circles) and other habitation sites (squares) listed in Table 8.2. See Figure 8.2 for the locations of sites 18, 20, and 24.

TABLE 8.2. Details of Terraced Hilltop and Other Habitation Sites (see Figures 8.2 and 8.5 for Locations).

No. on Figures 2 and 5	Site	Name	Site Type/ Setting	Size (m)	Surface Rock Rings/ Structures	Total Length of Terraces and Walls (m)	Conventional ¹⁴ C Date B.P.	Calibrated 2-Sigma Range	References*
0	C42-02	Cerro Rancherías	Terraced hilltop	60 × 40	6	50			1
1	C85-02	Cerro del Apache	Terraced hilltop	130 × 80	14	240			1
2	A47-18	Cerro la Cienega	Terraced hilltop	520 × 180	21	925			2
3	A47-19	La Fortaleza	Terraced hilltop	70 × 40	2	100			2
4	A47-20	Cerro San Cristobal	Terraced hilltop	340 × 100	1	540			2
5	A47-01	Cerro las Flojeras	Terraced hilltop	250 × 50	0	380	1260 ± 40	A.D. 670–880	1
6	A47-07	Cerro del Panteón	Terraced hilltop	110 × 60	3	300			2
7	A46-01	Cerro de los Apaches de Pichague	Terraced hilltop		0	100			2
8	A57-06	Cerro la Cieneguita	Terraced hilltop	170 × 80	0	130		Modern	2
9	A57-28	Boquilla de San José	Terraced hilltop	30 × 30	1	15			2
10	A57-25	Cerro Santo Domingo	Terraced hilltop	120 × 60	8	140			2
11	A57-01	Cerro Prieto	Terraced hilltop	120 × 80	10	300	3410 ± 40	1770–1620 B.C.	1, 3, 4
							1540 ± 50	A.D. 410–630	
							1360 ± 50	A.D. 620–770	
							1020 ± 40	A.D. 970–1040	
							400 ± 40	A.D. 1430–1530	
12	A58-02	La Noria	Terraced hilltop	100 × 80	3	300	1950 ± 50	50 B.C.–A.D. 140	1, 3, 4
13	A58-01	Cerro Talamantes	Terraced hilltop	120 × 50	9	350	1390 ± 40	A.D. 610–690	
14	A68-01	Cerro Maynez I	Terraced hilltop	175 × 100	7	570	1290 ± 40	A.D. 660–790	2
15	A68-02	Cerro Maynez II	Terraced hilltop	240 × 140	10	450	1460 ± 40	A.D. 540–660	2

16	—	Cerro Corrales	Terraced hilltop	340 × 140	53	2100	1260 ± 40 210 ± 40	A.D. 670–880 A.D. 1640–1950	3, 4
17	A15-06	Los Pilares	Alluvial terrace, buried pithouses	180 × 70	2†		140 ± 30 2910 ± 40 1840 ± 40 1850 ± 40 1110 ± 40 270 ± 40	A.D. 1670–1950 1260–1000 B.C. A.D. 80–250 A.D. 70–250 A.D. 870–1010 A.D. 1510–1800	1, 2, 5
18	A33-07		Mesa top, pithouse	45 × 25	1				1
19	A57-11		Ridgetop, pithouses, rock rings	360 × 30	6				2
20	A43-02		Mesa top, structures	35 × 45	3				1
21	A57-10	Sitio Delgado	Narrow ridge, structures	30 × 12	2				2
22	A57-27		Hillside, structures	50 × 30	3				2
23	A56-01	Sitio Caballero	Mesa top, structures	350 × 160	15		160 ± 40	A.D. 1660–1950	1

* 1, MacWilliams et al. (2006); 2, MacWilliams et al. (2009); 3, Raymond (2001); 4, Raymond et al. (2003); 5, MacWilliams et al. (2011).

† Pithouses were not visible on the surface.

at both of these sites were scattered in *ranchería* fashion (MacWilliams et al. 2006:31–32). Nearby in the same tributary is site A57-10, also with ceramics. This site has two residential structures built at the end of a narrow finger mesa surrounded on three sides by sheer cliffs. We also tested a multicomponent site (A15-06) that includes a large formal pithouse dating to ca. A.D. 100 as well as the partial remains of a later pithouse; neither was visible on the surface. It is located on an alluvial terrace above the Río San Pedro, about 90 km southwest of Chihuahua City.

Ethnohistorical Research and Settlement Types in Central and Southern Chihuahua

Complementing our archaeological data are accounts from the Spanish colonial period describing the people who were living in the three-month maize moisture zone at the time of European contact (Gerhard 1982:161–243; Griffen 1969, 1979; Pennington 1963, 1969). The eastern portions of the zone were occupied primarily by the Conchos, who are poorly documented and did not survive the colonial period as a distinct ethnic group. However, like the other major indigenous societies in the zone, the Tepehuanes and Tarahumaras, the Conchos lived in *rancherías* and practiced some agriculture along major drainages, although they appear to have relied more heavily on hunting and gathering than the other two societies (Álvarez 2000; Deeds 2003:51; Griffen 2000:258).⁶ The Tepehuan territory extended from the southern border of our focus area for about 600 km to the western Mexican state of Nayarit (Álvarez 2006; Berrojalbiz 2006a, 2006b; Pennington 1969:6–27; Wilcox et al. 2008:105).⁷

The Tarahumaras (the modern-day *Rarámuris*) occupied the western half of the zone, as well as the sierra that bears their name (Hard and Merrill 1992; Merrill 1988, 2001; Pennington 1963). A considerable portion of the Tarahumaras' original territory on the eastern flank of the Sierra Madre Occidental included wide river valleys where aggregation and increased crop production through agricultural intensification would have been possible (Figure 8.6). However, throughout their territory, they followed a dispersed, *ranchería* settlement strategy and a mixed foraging-farming subsistence strategy. In fact, for over two centuries, through both violent and passive means, they resisted missionary efforts to congregate them into aggregated settlements (Deeds 2003; Merrill 1993; Pennington 1963). The missionaries interpreted this resistance as a sign of the Tarahumaras' barbarity, but in condemning it, they also provided invaluable information on the Tarahumaras' subsistence-settlement strategies, as illustrated by excerpts from an unpublished seventeenth-century

report prepared by Joseph Tardá and Thomas de Guadalaxara, the Jesuit missionaries who established the majority of missions in the central portions of our focus area.

They do not live congregated but rather dispersed in their *ranchos* a good distance from one another, along the banks of the rivers. It is difficult to get them to congregate to form pueblos, and they tend to go continuously from one pueblo to another within their nation, although they do not go outside. . . . Because they live contentedly with few things, there is no one who can oppose their vices. Their houses are as easy for them to move as tents. They have few clothes, and it matters little to the wildest of them to go about naked. They have their food with little work because they only work in planting along the riverbanks where the ground is soft, and with what they harvest they have enough for all year, so they only labor a month or two working [the soil] and planting. They live in liberty, separated from one another, each in his *ranchito*, without having disagreements among themselves and spending the majority of the year traveling around and taking it easy.⁸

These missionaries also reported that five “pueblos” between Temichic and Papigochic (modern-day Guerrero) on the upper reaches of the Río Papigochic actually comprised rancherías that were “spread out over almost eighteen leagues,” equivalent to about 50 km (Figure 8.6).⁹

Aggregated Settlements within the Three-Month Maize Moisture Season Zone

Except for the terraced hill sites discussed above, evidence for substantial aggregation within the three-month maize moisture season zone begins in the upper Río Santa María Valley and the Babícora Basin, just north and west of the La Cruz complex sites. Kelley and her colleagues (2004:302) recorded 120 Medio period sites in these areas. Most have one or two mounds from room blocks; the largest is the site of La Raspadura, with up to 23 mounds. Also notable is the large Medio component of the El Zurdo site, with at least three main room blocks (Hodgetts 1996; Kelley and Larkin 2003; Kelley et al. 2004; Merrill and López González 2007).

The abundance of pueblo sites in the middle and lower reaches of the Río Casas Grandes watershed, in the one- and two-month maize moisture zones, leaves no doubt that the area was densely populated during the Medio period (A.D. 1200–1450) (Brand 1933; Whalen and Minnis 2001, 2009:68). People presumably intensively farmed the wide, well-watered Río Casas Grandes floodplain and its tributary valleys. They also

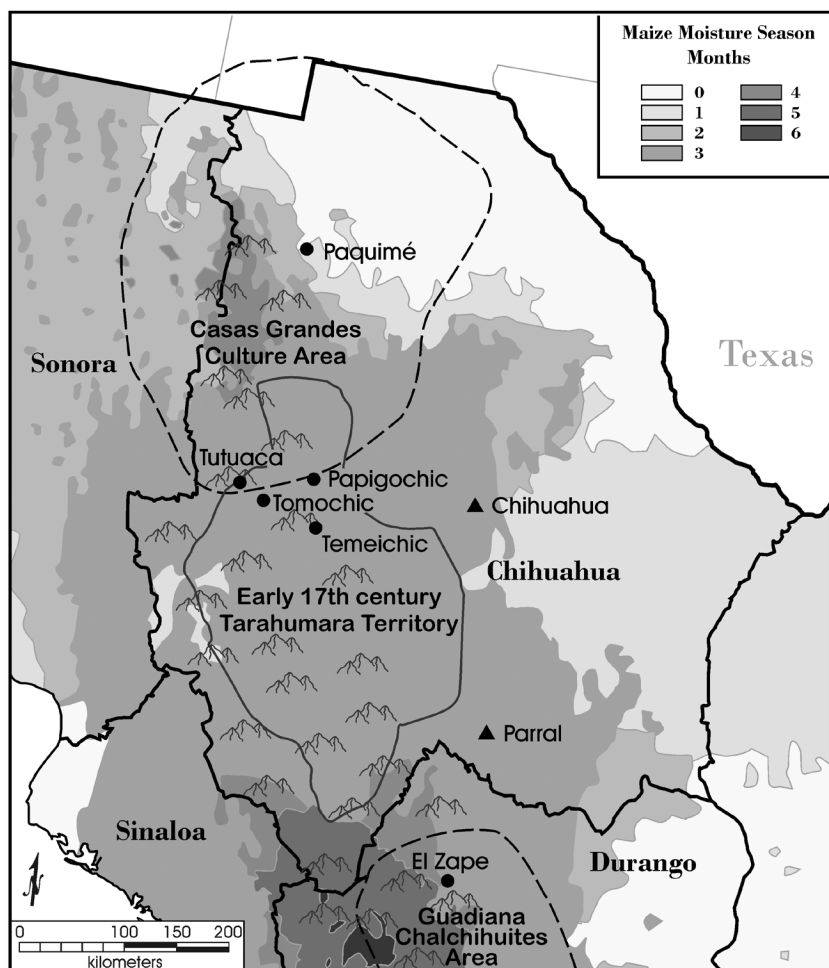


FIGURE 8.6. Early seventeenth-century territory of the Tarahumara (Merrill 1988:Frontispiece) and maize moisture months. Tarahumara territory closely corresponds to the three-month maize moisture season area.

constructed what appear to be irrigation canals, although all of the few known canals are above the floodplain (Doolittle 1993; Whalen and Minnis 2001). High densities of small to medium-size pueblos and a few primate centers created multiple scales of aggregation that shifted through time (Whalen and Minnis 2001:106–138, 2009:259–278). In the uplands, they built extensive complexes of linear stone alignments, check dams, and small canals to control runoff and increase soil moisture (Di

Peso 1984; Whalen and Minnis 2001:74–75, 2009:25). Such complex water management features are not found in southern Casas Grandes sites (Kelley et al. 2004:302).

In the far southern portion of our project area, one mesatop site with 15 foundations (A56-01) is similar to other sites discovered previously in southern Chihuahua and northern Durango (Foster 1978, 1985, 2000; Hers 1989, 2006; Kelley 1956).¹⁰ These sites often are located on mesatops and include small room blocks with rectangular quarters. Only a few of the larger sites, interpreted as villages, have evidence of communal structures, mounds, and plazas, but most sites are small and lack such features. Ethnobotanical remains recovered from La Cueva de los Muertos Chiquitos, located near El Zape, Durango, and dated to A.D. 660 (1300 ± 100 B.P.), indicate that the Ceramic period residents of the area had a broad-based diet with a generous variety of beans, squashes, and maize (Brooks et al. 1962:368).

Major aggregated settlements associated with the Chalchihuites tradition extend as far north as the El Zape area of Durango (Foster 2000; Hers 2006). Chalchihuites sites are encountered in a narrow corridor of clear Mesoamerican affiliation that extends in a northwest-to-southeast direction from this area to the region of La Quemada in southern Zacatecas (Carot and Hers 2008; Foster 2000; Hers 2001; Kelley 1971; Mason 1971). The spread of Chalchihuites culture from Zacatecas into western Durango, known as Guadiana Chalchihuites (Figure 8.1), began around A.D. 600 and continued northward to the El Zape area, disappearing from Durango around A.D. 1400 (Foster 2000). Located only 100 km south of the southern boundary of our 2002–2009 project area, the El Zape sites are characterized by dense house mounds, low platform mounds, associated plazas, patios, circular rooms, and stairways with stone carvings and Mesoamerican ceramics (Foster 2000).

Settlement Strategies and Rain-Fed Farming

Our hypothesis is that the viability of rain-fed farming was a significant factor in the emergence and persistence of a dispersed, rancheria settlement strategy and a mixed farming-foraging subsistence strategy in those portions of the three-month maize moisture zone in central and southern Chihuahua where little evidence of aggregated settlements has been found. Interannual agricultural production may have been more variable in areas within the three-month maize moisture zone using rain-fed strategies than areas with longer maize moisture seasons or water management systems. Typically, under conditions of variable or low agricultural productivity, populations remain below carrying capacity, and risk

is managed through higher mobility, greater use of wild foods, and little aggregation (Kohler 2004b; Kohler and Van West 1996; Orcutt 1999). In contrast, under conditions of high agricultural productivity coupled with high environmental variability, growing populations intensify agricultural production and aggregate to participate in reciprocal relationships and storage to offset harvest shortfalls. Market formation that works with specialization can supplement household reciprocity and contribute to aggregation (Cordell et al. 1994; Kohler 2004b; Kohler et al. 2004). Thus, key variables in adopting a dispersed vs. aggregated settlement strategy are risk management strategies, the potential for mobility, population density relative to resources, and the role of wild foods.

The archaeological data from the area proposed for rancheria settlements suggests that rain-fed farming probably was the principal cultivation technique, given the absence of any evidence for more labor-intensive forms of irrigation. They could, of course, have practiced simpler forms of irrigation involving the diversion of water from springs or streams, as well as dry farming, water-table farming, flood farming, and runoff farming where local topographic and hydrological conditions were appropriate. The significance of rain-fed farming for reinforcing a rancheria and mixed farming-foraging settlement-subsistence strategy that was flexible and resilient is one line of evidence supporting our hypothesis. A second line of evidence is based on ethnographic and linguistic data, which allow at least partial reconstructions of some relevant aspects of Tarahumara culture for the pre-European contact and early contact periods.

Rain-fed farming facilitates population dispersion, as there should be more and a wider range of niches available for cultivation. Farmers could build their homes adjacent to their fields, thus reducing costs of travel and transport and risks from crop destruction by wildlife.

The risk of crop loss due to highly localized weather events, such as hailstorms, floods, and early frosts, could be minimized by having multiple fields in slightly different settings. During droughts, people with multiple fields would have more flexibility in either dispersing to springs or settling along permanent streams.

The members of these rancheria societies could also reduce risk by emphasizing mobility and collecting wild foods. In irrigation farming systems reliant on elaborate water management systems, fields are difficult to abandon because they represent significant labor investments and may be associated with social obligations related to maintaining the irrigation systems. In contrast, rain-fed fields have little labor invested in them and can be readily replaced by fields in other places where rain-fed farming is possible. Rain-fed farming strategies thus facilitate mobility, and the possibility for such mobility to obtain wild foods can offset risk in dry years.

However, the potential to produce significant surpluses may be limited in the three-month maize moisture zones characterized by high interannual variability. Additionally, the benefits conferred by rain-fed farming may begin to disappear if population density relative to potential farming niches reaches high levels. At higher population densities, even with rain-fed farming, agricultural intensification and aggregation are likely to occur but will be mediated by other variables (see, e.g., Sanders et al. 1979).

In the seventeenth century, when the Spanish colonial system expanded into the area where the Tarahumara language was spoken, the Tarahumaras' territory was extensive, covering approximately 45,000 km² (Merrill 1988:30). The size of this territory suggests that the Tarahumara population had previously experienced significant growth and that their response was not agricultural intensification and aggregation but rather expansion into new areas suitable for rain-fed agriculture. In fact, the boundaries of the aboriginal Tarahumara homeland corresponded eerily close to those of the three-month maize moisture season area (Figure 8.6), suggesting that arable lands within the three-month maize moisture zone represented the niche to which the Tarahumaras' farming strategy was adapted, with adjacent uncultivated areas providing wild resources that were the focus of their hunting and gathering activities.

The odd northern handle of their territory (Figure 8.6) may indicate that Tarahumara expansion farther north was blocked by the presence of bearers of the Casas Grandes cultural tradition or their descendants after Casas Grandes society collapsed. However, the deeper cultural history of speakers of Tarahumara and other languages that belong to the southern branch of the Uto-Aztecan language family suggests that the Proto-Southern Uto-Aztecan speech community was located in the Serrana region of northeastern Sonora when its members first adopted maize agriculture. The dispersal of this speech community to the west, south, and east was at least in part the result of the need for new farming lands to support a growing population (Merrill 2012, 2013).¹¹

The ancestral Tarahumaras probably expanded from this Southern Uto-Aztecan homeland through northwestern Chihuahua and then down the eastern flanks of the Sierra Madre Occidental and farther east to central Chihuahua. If this scenario represents what actually occurred, then their distant ancestors in far northwestern Chihuahua could have been involved in the creation of the Casa Grandes cultural tradition or absorbed by its bearers. Alternatively, they could have been displaced from the more northerly areas of their original territory by Casas Grandes people or, after the collapse of Paquimé, by their descendants.

The expansion of rancheria settlements within the three-month maize moisture zone would account for the absence of evidence for both population growth in specific settlements and wild resource depletion, as may

have occurred at Paquimé (Merrill and López González 2007:57). In addition, factors often considered key to promoting aggregation, like the need for defense, may not have been operative in central and southern Chihuahua. For example, prior to the European colonization of Tarahumara territory, there is but one mention of any conflict there, even though extensive communication existed between the Tarahumaras and Spanish missionaries, traders, and officials. In this one example, Tepehuanes and Tarahumaras who lived just beyond the colonial frontier in northwestern Durango and southern Chihuahua had established an alliance against other Tarahumaras who lived about 200 km farther to the north (Giudicelli 2006; González Rodríguez 1984:160, 178–179). Because these interethnic alliances were being formed along the colonial frontier, control of access to European goods or possibly to the trade in indigenous slaves may have been involved.

It is clear that in the *rancheria* area of central Chihuahua, high regional population density and aggregated settlement do not always co-occur (Merrill 1991). Tarahumara demographic data come from a 1725 Jesuit census of their missions by the Jesuit Juan de Guedulain; this is the first official census of the northern missions.¹² Gerhard (1982:188–189) provides details from the Tarahumara missions of Tomochic and Tutuaca, which covered about 3,300 km². The missionary at Tomochic was also responsible for Tutuaca, which lacked a resident mission in 1725.¹³ In both missions, the vast majority of Tarahumaras lived dispersed in their *rancherías*. They temporarily congregated in the mission pueblos for religious celebrations, as well as to discuss and resolve issues related to the communities' political, judicial, and economic affairs (Deeds 2003; Merrill 1993).

Gerhard reports that 3,165 indigenous people were affiliated with these two missions, representing slightly less than one (.96) person per km². By this point in Tarahumara history, epidemics and wars with European settlers, as well as slaving and other forms of forced labor, had already substantially reduced the population from precontact levels.¹⁴ In addition, the census data, often provided by the resident missionaries rather than being based on actual head counts, undoubtedly underestimated the population and did not include many indigenous people who rejected an affiliation with the missions and the Catholic religion. Nonetheless, such population densities are stunning when compared to those reconstructed for the American Southwest. Hill and colleagues (2004:689–693), for example, estimate the peak population density of the Hohokam to have been 40,000 people in a 100,000 km² area, or .4 person per km².¹⁵

The opposite end of the dispersed-aggregated settlement continuum is represented in the three-month maize moisture zone by the Casas Grandes and Guadiana Chalchihuites aggregated settlements, as well

as the terraced hill sites. These sites demonstrate that the associated precipitation regime did not preclude aggregated settlements. Although no one would propose that the emergence of aggregation in a particular society was the result of the personal preferences of its members, individuals from aggregated settlements who were expanding into new areas might be inclined to re-create aggregated settlements. Such cultural factors need to be taken into consideration when trying to account for the aggregation of Guadiana Chalchihuites settlements. In the case of the southern Casas Grandes sites, which were not established as the result of expansion, settlement aggregation may reflect the operation of factors related to exchange, forms of labor organization, and other social processes that promoted aggregation (Kohler 2004b) or participation in traditions where aggregated settlements were considered culturally superior to dispersed settlements.¹⁶ Although Casserino (2009) raises serious doubts about long-held assumptions of a high degree of intersocietal violence in the Casas Grandes area, the need for defense under conditions of chronic raiding or warfare might apply to some terraced hill sites and Chalchihuites centers (Elliott 2005; LeBlanc 1999; Nelson 1995, 1997, 2000; cf. Pitezel 2011; Weigand 1975).

Conclusions

In this chapter, we have addressed an enigmatic aspect of Chihuahua archaeology. We propose that the apparent 300-km gap in aggregated settlements between the Casas Grandes and the Chalchihuites regions is related to a precipitation regime that allowed for successful rain-fed farming. This subsistence system reinforced a dispersed settlement strategy. The resilience of this adaptation was based in part on the options for mobility—presumably both logistical and residential mobility for both farming and foraging—that rain-fed farming enabled. The lack of significant tethering to highly localized water sources or irrigation works allowed population densities to remain high, though they were distributed across the landscape. This situation allowed people to be relatively flexible in dealing with precipitation vagaries and likely reduced localized wild resource depletion. In other words, with rain-fed strategies a greater proportion of the landscape can support agricultural fields.

This adaptation contrasts sharply with aggregated and probably mostly sedentary populations of northwestern Chihuahua and western Durango. Clearly, processes of population increase, agricultural intensification, and surplus production were significant factors in the development of the moisture-capture strategies of the highly productive river valleys of the Casas Grandes cultural tradition nearer to Paquimé. Similar processes

presumably were involved in the expansion of the Chalchihuites tradition into western and northern Durango, but in this case the longer maize moisture seasons increased possibilities for the production of agricultural surpluses, which would have been advantageous for the expansion of Guadiana Chalchihuites aggregated settlements over areas that covered a stretch of more than 500 km.

Although possibilities for rain-fed farming are much more limited in the southwestern United States than in northern Mexico, dispersed farming settlements are and were widespread, and dispersed settlement strategies characterized many areas of the region at multiple points in time and under a variety of moisture conditions. A range of archaeological models investigating the roles of ecological, demographic, economic, social, political, and other cultural variables has been proposed to account for aggregated and dispersed settlement strategies in the Southwest (e.g., Adler 1994; Cordell et al. 1994; Kohler et al. 2004). Assessing the relative significance of rain-fed farming and other moisture-capture techniques as a factor affecting settlement strategies in the Southwest is difficult because rain-fed farming as practiced by ancient indigenous people cannot be observed, and so many other independent and dependent variables such as population density, subsistence, ecological setting, paleoecology, agricultural potential, wild food resources, and culture are all key variables for understanding the persistence of rancheria settlements and aggregation.

The interplay of these variables and their impact on settlement strategies present major challenges to our understanding of aggregation. One research strategy would be to examine the exceptions to the model proposed here. For example, the aggregated Medio period pueblos and hilltop sites in central and southern Chihuahua show that there is no necessary relationship between moisture regime and settlement strategies. The fact that we do not understand such exceptions leads to the formulation of a series of questions designed to investigate why aggregation occurs at locations where a rancheria strategy is possible. Initial questions include: Are our macroscopic classifications of these locations accurate? Was rain-fed farming possible at the time the aggregated settlements were in use? Other questions follow: What agricultural and wild plant use strategies were being practiced at these locations? What is the temporal dimension of aggregation? What was the settlement strategy of the Viejo period sites that preceded the Medio period sites? Do the hilltop sites in southern Chihuahua primarily occur at A.D. 500–900 as we suggest? The basic data gathered during the course of such research could be used to generate models that explore various hypotheses related to the formation of aggregated sites. Hypotheses regarding other factors such as warfare, risk reduction, and intensification could also be evaluated

through additional fieldwork. This research strategy not only clarifies what we do not know and identifies clear questions relevant to addressing broad anthropological issues but also advances our understanding of Chihuahuan archaeology.

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Notes

1. "Rain-fed farming" is the English equivalent of the Spanish term "*temporal*."
2. We also conducted limited reconnaissance and testing in the Sierra Tarahumara as part of our 2002–2009 work, and no evidence of prehispanic aggregation was found.
3. Hodson and colleagues (2002) calculate soil moisture levels from monthly mean climatic data (30-year averages), taking into consideration both precipitation and evapotranspiration. When the ratio of precipitation to potential evapotranspiration is greater than .5 for a month, then soil moisture is assumed to be available for maize growth. This estimate is based on global comparisons with actual maize-planting dates (Hartkamp et al. 2000).
4. All of these sites are described in detail in MacWilliams et al. (2006, 2009) and Raymond (2001).

5. We have an oral account from the Mexican Revolution of civilians from Villa Lopez taking refuge on this site when fighting swept through the area. The historic period radiocarbon date may corroborate this account. There is a possibility that some of the constructions may be more recent.

6. The earliest Spanish explorers of Chihuahua reported Concho farmers living in rancherías along the Río Conchos and other ethnic groups living in aggregated farming settlements in the vicinity of the juncture of the Río Conchos and Río Grande (Kelley 1952:264). The latter area, known as La Junta de los Ríos, is characterized by J. Charles Kelley (1952:262) as being unable to “support agriculture except through irrigation.”

7. Although the Tepehuanes are assumed to have generally followed a dispersed settlement strategy, one of the first Jesuit missionaries among them reported that some Tepehuan settlements in the Sierra de Ocotlán were aggregated. He noted that these settlements were located about 120 km (40 leagues) from the closest mission, with the first 60 km depopulated. He described the settlements as consisting of five “pueblos” that were true villages, with fixed lands, separated from one another by from 9 to 12 km, and that their food was “maize, beans, and fish in abundance” (González Rodríguez 1984:156, our translation). The depopulated zone suggests that defense against enslavement and other forms of forced labor practiced on the Spanish frontier may have been a factor in the formation of these aggregated settlements (Cuellar 1988; Yeager 1995).

8. Letter to Provincial Francisco Ximénez, August 15, 1676, *Mexicana* 17, fols. 364r–364v, 377v, Archivum Romanum Societatis Iesu (ARSI), Rome, translation by William Merrill.

9. *Mexicana* 17, fol. 371r, ARSI, Rome.

10. J. Charles Kelley (1971) and Michael Foster (2000) classify these sites as belonging to the Loma San Gabriel tradition, but Hers (1989) argues that the sites in question are the northernmost expression of Chalchihuites culture.

11. The earliest evidence for maize agriculture in the vicinity of the Serrano region comes from the Tucson Basin, located 150 km to the north. It dates to ca. 2100 B.C. (Merrill et al. 2009). Most of the documented languages spoken between northwestern Mexico and Mesoamerica belong to the southern branch of the Uto-Aztecan language family, including Yaqui-Mayo, Northern and Southern Tepehuan, Cora, Huichol, and Nahuatl (Campbell 1997:133–138; Merrill 2012, 2013; Miller 1983).

12. Letter to Provincial Gaspar Roder, Cócorin, Sinaloa, December 22, 1725, *Jesuitas* II-4, expediente 32, Archivo General de la Nación (AGN), Mexico City.

13. Gerhard (1982:387n22) relied on an eighteenth-century copy of the original Guendulain report, housed in the AGN (*Historia* 20, fols. 18v–32). Although the colonial scribe took liberties in preparing the transcription, the population counts in the copy are exactly the same as in the original.

14. Gerhard (1982:17, 188–191) presents his analysis of the demographic data from the missions of Tomchic and Tutuaca in the section on the political

jurisdiction (*intendencia*) of Cosihuiriáchic (today, Cusihuiriachi). The organization of these jurisdictions into *intendencias* did not occur until the late eighteenth century in Chihuahua, but this anachronism does not affect the validity of his analysis. Based on reports of population declines that he gleaned from unpublished archival sources, Gerhard provides estimates of the populations of these missions and of the entire territory later assigned to Cosihuiriáchic in 1600, just prior to European contact in this part of Chihuahua. The Cosihuiriáchic jurisdiction covered an area of approximately 39,000 km². For Tomochic and Tutuaca, he estimates the population to number 8,000 people in an area of 3,300 km² (2.42 persons per km²); for Cosihuiriáchic, 77,000 (1.97 persons per km²). He also estimates that in 1702, a century after European contact, the indigenous population of the Cosihuiriáchic jurisdiction had dropped to 36,000 (.92 person per km²).

15. If only the Phoenix Basin were considered, Hohokam population density was much higher, 4–6 people per km² (Hegmon et al. 2008:Table 1; Hill et al. 2004:695).

16. Europeans certainly regarded aggregated settlements laid out in a grid-like pattern of streets and plazas to be a hallmark of civilization and a dispersed settlement pattern to express a state of savagery (Borges 1987:142–146; Foster 1960:34–49; Stanislawski 1947). There was, however, some difference of opinion on the matter. In the late sixteenth century, a Franciscan missionary and a high-ranking Spanish official debated whether forcing Indians to live in aggregated settlements would contribute significantly to their transformation into “civilized” Christians. The official, a native of the province of Galicia, pointed out that people in Galicia and also the Basque provinces lived dispersed through the hills and valleys but that this settlement pattern did not prevent them from being Christians. The Franciscan responded to the effect that, if the Galicians and Basques lived in towns, they probably would be better Christians and also more civilized (Borges 1987:107).

References Cited

- Adams, Karen R. 2013. Ancient Plant Use in West-Central Chihuahua. Manuscript on file with the author, Tucson, Arizona.
- Adams, Karen R., and Kenneth Lee Petersen. 1999. Environment. In *Colorado Prehistory: A Context for the Southern Colorado River Basin*, edited by William D. Lipe, Mark D. Varien, and Richard H. Wilshusen, pp. 14–34. Colorado Council of Professional Archaeologists, Denver.
- Adler, Michael. 1994. Population Aggregation and the Anasazi Social Landscape: A View from the Four Corners. In *The Ancient Southwestern Community: Models and Methods for the Study of Prehistoric Social Organization*, edited by W. H. Wills and Robert D. Leonard, pp. 85–101. University of New Mexico Press, Albuquerque.

- Álvarez, Salvador. 2000. Agricultores de paz y cazadores-recolectores de guerra: Los tobosos de la cuenca del Río Conchos en la Nueva Vizcaya. In *Nómadas y sedentarios en el norte de México: Homenaje a Beatriz Braniff*, edited by Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebuena, pp. 305–354. Universidad Nacional Autónoma de México, Mexico City.
- . 2006. De “zacatecos” y “tepehuanes”: Dos dilatadas parcialidades de chichimecas norteños. In *La Sierra Tepehuana: Asentamientos y movimientos de población*, edited by Chantal Cramaussel and Sara Ortelli, pp. 97–128. El Colegio de Michoacán, Zamora; Universidad Juárez del Estado de Durango, Instituto de Investigaciones Históricas, Durango.
- Anschuetz, Kurt F., Richard H. Wilshusen, and Cherie L. Scheick. 2001. An Archaeology of Landscapes: Perspectives and Directions. *Journal of Archaeological Research* 9:157–211.
- Berrojalbiz, Fernando. 2006a. Desentrañano un norte diferente: Tepehuanes prehispánicos del alto Río Ramos, Durango. In *La Sierra Tepehuana: Asentamientos y movimientos de población*, edited by Chantal Cramaussel and Sara Ortelli, pp. 67–95. El Colegio de Michoacán, Zamora; Universidad Juárez del Estado de Durango, Instituto de Investigaciones Históricas, Durango.
- . 2006b. El origen norteño de los tepehuanes: Elementos arqueológicos sobre la antigua relación tepima. In *Las vías del noroeste I: Una macroregión indígena americana*, edited by Carlo Bonfiglioli, Arturo Gutiérrez, and María Eugenia Olavarría, pp. 83–112. Universidad Nacional Autónoma de México, Instituto de Investigaciones Antropológicas, Mexico City.
- Borges, Pedro. 1987. *Misión y civilización en América*. Editorial Alhambra, Madrid.
- Brand, Donald D. 1933. The Historical Geography of Northwest Chihuahua. Unpublished Ph.D. dissertation, University of California, Berkeley.
- . 1939. Notes on the Geography and Archaeology of Zape, Durango. In *So Live the Works of Men*, edited by Donald D. Brand and Fred E. Harvey, pp. 75–105. University of New Mexico Press, Albuquerque.
- Brooks, Richard H. 1971. Lithic Traditions in Northwestern Mexico, Paleo-Indian to Chalchihuites. Unpublished Ph.D. dissertation, University of Colorado, Boulder.
- Brooks, Richard H., Lawrence Kaplan, Hugh C. Cutler, and Thomas W. Whitaker. 1962. Plant Material from a Cave on the Río Zape, Durango, Mexico. *American Antiquity* 27:356–369.
- Campbell, Lyle. 1997. *American Indian Languages: The Historical Linguistics of Native America*. Oxford University Press, Oxford.
- Carot, Patricia, and Marie-Areti Hers. 2008. Epic of the Toltec Chichimec and the Purépecha in the Ancient Southwest. In *Archaeology without Borders: Contact, Commerce, and Change in the U.S. Southwest and Northwestern Mexico*, edited by Laurie D. Webster and Maxine E. McBrinn, pp. 301–333. University Press of Colorado, Boulder.

- Casserino, Christopher M. 2009. Bioarchaeology of Violence and Site Abandonment at Casas Grandes, Chihuahua, Mexico. Unpublished Ph.D. dissertation, University of Oregon, Eugene.
- Cordell, Linda S. 1994. Introduction: Community Dynamics of Population Aggregation in the Prehistoric Southwest. In *The Ancient Southwestern Community: Models and Methods for the Study of Prehistoric Social Organization*, edited by W. H. Wills and Robert D. Leonard, pp. 79–83. University of New Mexico Press, Albuquerque.
- Cordell, Linda S., David E. Doyel, and Keith W. Kintigh. 1994. Processes of Aggregation in the Prehistoric Southwest. In *Themes in Southwest Prehistory*, edited by George J. Gumerman, pp. 109–133. School of American Research Press, Santa Fe.
- Cordell, Linda S., and Fred Plog. 1979. Escaping the Confines of Normative Thought: A Reevaluation of Puebloan Prehistory. *American Antiquity* 44:405–429.
- Crown, Patricia L., and Timothy A. Kohler. 1994. Community Dynamics, Site Structure, and Aggregation in the Northern Rio Grande. In *The Ancient Southwestern Community: Models and Methods for the Study of Prehistoric Social Organization*, edited by W. H. Wills and Robert D. Leonard, pp. 103–117. University of New Mexico Press, Albuquerque.
- Cuello, José. 1988. The Persistence of Indian Slavery and Encomienda in the Northeast of Colonial Mexico, 1577–1723. *Journal of Social History* 21:683–700.
- Deeds, Susan M. 2003. *Defiance and Deference in Mexico's Colonial North: Indians under Spanish Rule in Nueva Vizcaya*. University of Texas Press, Austin.
- Díaz, Sara C., Matthew D. Therrell, David W. Stahle, and Malcolm K. Cleaveland. 2002. Chihuahua (Mexico) Winter-Spring Precipitation Reconstructed from Tree-Rings, 1647–1992. *Climate Research* 22:237–244.
- Di Peso, Charles C. 1984. The Structure of the 11th Century Casas Grandes Agricultural System. In *Prehistoric Agricultural Strategies in the Southwest*, edited by Suzanne K. Fish and Paul R. Fish, pp. 261–269. Anthropological Research Papers 33. Arizona State University, Tempe.
- Doolittle, William E. 1993. Canal Irrigation at Casas Grandes: A Technological and Developmental Assessment of Its Origins. In *Culture and Contact: Charles C. Di Peso's Gran Chichimeca*, edited by Anne I. Woosley and John C. Ravesloot, pp. 133–151. Amerind Foundation, Dragoon, Arizona, and University of New Mexico Press, Albuquerque.
- Elliott, Michelle. 2005. Evaluating Evidence for Warfare and Environmental Stress in Settlement Pattern Data from the Malpaso Valley, Zacatecas, Mexico. *Journal of Anthropological Archaeology* 24:297–315.
- Endfield, Georgina H. 2007. Archival Explorations of Climate Variability and Social Vulnerability in Colonial Mexico. *Climatic Change* 83:9–38.
- . 2008. *Climate and Society in Colonial Mexico: A Study in Vulnerability*. Blackwell Publishing, Malden, Massachusetts.

- Endfield, Georgina H., and I. Fernández-Tejedo. 2006. Decades of Drought, Years of Hunger: Archival Investigations of Multiple Year Droughts in Late Colonial Chihuahua. *Climatic Change* 75:391–419.
- Fish, Paul R., Suzanne K. Fish, and M. Elisa Villalpando (editors). 2007. *Trincheras Sites in Time, Space, and Society*. University of Arizona Press, Tucson.
- Foster, George M. 1960. *Culture and Conquest: America's Spanish Heritage*. Wenner-Gren Foundation for Anthropological Research, New York.
- Foster, Michael S. 1978. Loma San Gabriel: A Prehistoric Culture of Northwest Mexico. Unpublished Ph.D. dissertation, University of Colorado, Boulder.
- . 1985. The Loma San Gabriel Occupation of Zacatecas and Durango, Mexico. In *The Archaeology of West and Northwest Mesoamerica*, edited by Michael S. Foster and Phil C. Weigand, pp. 327–351. Westview Press, Boulder.
- . 2000. The Archaeology of Durango. In *Greater Mesoamerica: The Archaeology of West and Northwest Mexico*, edited by Michael S. Foster and Shirley Gorenstein, pp. 197–219. University of Utah Press, Salt Lake City.
- García, Enriqueta, Rosalía Vidal, Luz Ma. Tamayo, Teresa Reyna, Rubén Sánchez, Margarita Soto, and Enrique Soto. 1973a. *Precipitación y probabilidad de lluvia en la República Mexicana y su evaluación: Chihuahua*. Climas 17. Instituto de Geografía, U.N.A.M. y Comisión de Estudios del Territorio Nacional, Mexico City.
- . 1973b. *Precipitación y probabilidad de lluvia en la República Mexicana y su evaluación: Durango*. Climas 15. Instituto de Geografía, U.N.A.M. y Comisión de Estudios del Territorio Nacional, Mexico City.
- Gerhard, Peter. 1982. *The North Frontier of New Spain*. Princeton University Press, Princeton, New Jersey.
- Giudicelli, Christophe. 2006. Un cierre de fronteras . . . taxonómico. Tepehuanes y tarahumara después de la guerra de los tepehuanes (1616–1631). *Anuario IEHS* 21:59–78.
- González Rodríguez, Luis. 1984. *Crónicas de la Sierra Tarahumara*. Secretaría de Educación Pública, Mexico City.
- Griffen, William B. 1969. *Culture Change and Shifting Populations in Central Northern Mexico*. University of Arizona Press, Tucson.
- . 1979. *Indian Assimilation in the Franciscan Area of Nueva Vizcaya*. University of Arizona Press, Tucson.
- . 2000. Observations on the Limitations of Data on the Ethnohistory of Northern Mexico. In *Nómadas y sedentarios en el norte de México: Homenaje a Beatriz Braniff*, edited by Marie-Areti Hers, José Luis Mirafuentes, María de los Dolores Soto, and Miguel Vallebuena, pp. 249–273. Universidad Nacional Autónoma de México, Mexico City.
- Guevara Sánchez, Arturo. 1992. Un sitio arqueológico aldeano de Namiquipa, Chihuahua. In *Actas de Tercer Congreso Internacional de Historia Regional Comparada*, edited by Ricardo León García, pp. 41–45. Universidad Autónoma de Ciudad Juárez, Ciudad Juárez.

- Hard, Robert J., and William L. Merrill. 1992. Mobile Agriculturalists and the Emergence of Sedentism: Perspectives from Northern Mexico. *American Anthropologist* 94:601–620.
- Hartkamp, A. D., J. W. White, A. Rodríguez Aguilar, M. Bänziger, G. Srinivasan, G. Granados, and J. Crossa. 2000. *Maize Production Environments Revisited: A GIS-Based Approach*. CIMMYT, Mexico City.
- Hegmon, Michelle, Matthew A. Peeples, Ann P. Kinzig, Stephanie Kulow, Cathryn M. Meegan, and Margaret C. Nelson. 2008. Social Transformation and Its Human Costs in the Prehispanic U.S. Southwest. *American Anthropologist* 110:313–324.
- Hers, Marie-Areti. 1989. ¿Existió la cultura Loma San Gabriel? El caso de Cerro Hervideros, Durango. *Anales del Instituto de Investigaciones Estéticas* 60:33–57.
- . 2001. Zacatecas y Durango. Los confines tolteca-chichimecas. In *La gran chichimeca: El lugar de las rocas secas*, edited by Beatriz Braniff C., pp. 113–154. Consejo Nacional para la Cultura y las Artes, Mexico City.
- . 2006. La Sierra Tepehuana: Imágenes y discordancias sobre su pasado prehispánico. In *La Sierra Tepehuana: Asentamientos y movimientos de población*, edited by Chantal Cramaussel and Sara Orтели, pp. 17–43. El Colegio de Michoacán, Zamora; Universidad Juárez del Estado de Durango, Instituto de Investigaciones Históricas, Durango.
- Hewett, Edgar L. 1993. *Ancient Communities in the American Desert*. Translated by Madeleine Turrell Rodack. Reprinted. Archaeological Society of New Mexico Monograph Series 1. Albuquerque. Originally published 1908 as *Les communautés anciennes dans le désert américain*.
- Hill, J. Brett, Jeffery J. Clark, William H. Doelle, and Patrick D. Lyons. 2004. Prehistoric Demography in the Southwest: Migration, Coalescence, and Hohokam Population Decline. *American Antiquity* 69:689–716.
- Hill, James N., W. Nicholas Trierweiler, and Robert W. Preucel. 1996. The Evolution of Cultural Complexity: A Case from the Pajarito Plateau, New Mexico. In *Emergent Complexity: The Evolution of Intermediate Societies*, edited by Jeanne E. Arnold, pp. 107–127. International Monographs in Prehistory. Ann Arbor, Michigan.
- Hodgetts, Lisa M. 1996. Faunal Evidence from El Zurdo. *Kiva* 62:149–170.
- Hodson, D. P., E. Martínez-Romero, J. W. White, J. D. Corbett, and M. Bänziger. 2002. Latin America Maize Research Atlas (V1.0). CD-ROM. CIMMYT, Mexico City.
- Kelley, J. Charles. 1952. The Historic Indian Pueblos of La Junta de los Ríos. *New Mexico Historical Review* 27:257–295.
- . 1956. Settlement Patterns in North-Central Mexico. In *Prehistoric Settlement Patterns in the New World*, edited by Gordon R. Willey, pp. 128–139. Viking Fund Publications in Anthropology 23. Wenner Gren Foundation for Anthropological Research, New York.

- . 1971. Archaeology of the Northern Frontier: Zacatecas and Durango. In *Archaeology of Northern Mesoamerica*, edited by Gordon F. Ekholm and Ignacio Bernal, pp. 768–801. Handbook of Mesoamerican Indians Vol. 11, Pt. 2, Robert Wauchope, general editor. University of Texas Press, Austin.
- Kelley, Jane H., and Karin Burd Larkin. 2003. The Southern Zone of the Chihuahua Culture. *Archaeology Southwest* 17:8.
- Kelley, Jane H., Joe D. Stewart, A. C. MacWilliams, and Karen R. Adams. 2004. Recent Research in West-Central Chihuahua. In *Identity, Feasting, and the Archaeology of the Greater Southwest*, edited by Barbara J. Mills, pp. 295–310. University Press of Colorado, Boulder.
- Kelley, Jane H., Joe D. Stewart, A. C. MacWilliams, and Loy C. Neff. 1999. A West Central Chihuahua Perspective on Chihuahuan Culture. In *The Casas Grandes World*, edited by Curtis F. Schaafsma and Carroll L. Riley, pp. 63–77. University of Utah Press, Salt Lake City.
- Kim, Tae-Woong, Juan B. Valdés, and Javier Aparicio. 2002. Frequency and Spatial Characteristics of Droughts in the Conchos River Basin, Mexico. *Water International* 27:420–430.
- Kintigh, Keith W. 1994. Chaco, Communal Architecture, and Cibolan Aggregation. In *The Ancient Southwestern Community: Models and Methods for the Study of Prehistoric Social Organization*, edited by W. H. Wills and Robert D. Leonard, pp. 131–140. University of New Mexico Press, Albuquerque.
- Kohler, Timothy A. (editor). 2004a. *Archaeology of Bandelier National Monument: Village Formation on the Pajarito Plateau, New Mexico*. University of New Mexico Press, Albuquerque.
- . 2004b. Introduction. In *Archaeology of Bandelier National Monument: Village Formation on the Pajarito Plateau, New Mexico*, edited by Timothy A. Kohler, pp. 1–17. University of New Mexico Press, Albuquerque.
- Kohler, Timothy A., Robert P. Powers, and Janet D. Orcutt. 2004. Bandelier from Hamlets to Towns. In *Archaeology of Bandelier National Monument: Village Formation on the Pajarito Plateau, New Mexico*, edited by Timothy A. Kohler, pp. 293–303. University of New Mexico Press, Albuquerque.
- Kohler, Timothy A., and Carla Van West. 1996. The Calculus of Self-Interest in the Development of Cooperation: Sociopolitical Development and Risk among the Northern Anasazi. In *Evolving Complexity and Environmental Risk in the Prehistoric Southwest*, edited by Joseph A. Tainter and Bonnie Bagley Tainter, pp. 169–196. Santa Fe Institute Studies in the Sciences of Complexity, Proceedings 24. Addison-Wesley, Reading, Massachusetts.
- Larkin, Karin Burd, Jane H. Kelley, and Mitchell J. Hendrickson. 2004. Ceramics as Temporal and Spatial Indicators in Chihuahua Cultures. In *Surveying the Archaeology of Northwest Mexico*, edited by Gillian E. Newell and Emiliano Gallaga, pp. 177–204. University of Utah Press, Salt Lake City.
- LeBlanc, Steven A. 1999. *Prehistoric Warfare in the American Southwest*. University of Utah Press, Salt Lake City.

- Leonard, Robert D., and Heidi E. Reed. 1993. Population Aggregation in the Prehistoric American Southwest: A Selectionist Model. *American Antiquity* 58:648–661.
- Lipe, William D. 1994. Comments on Population Aggregation and Community Organization. In *The Ancient Southwestern Community: Models and Methods for the Study of Prehistoric Social Organization*, edited by W. H. Wills and Robert D. Leonard, pp. 141–143. University of New Mexico Press, Albuquerque.
- . 2010. Lost in Transit: The Central Mesa Verde Archaeological Complex. In *Leaving Mesa Verde: Peril and Change in the Thirteenth-Century Southwest*, edited by Timothy A. Kohler, Mark D. Varien, and Aaron M. Wright, pp. 262–284. Amerind Studies in Archaeology, John Ware, general editor. University of Arizona Press, Tucson.
- Longacre, William A. 1966. Changing Patterns of Social Integration: A Prehistoric Example from the American Southwest. *American Anthropologist* 68:94–102.
- Mabry, Jonathan B. 2005. Diversity in Early Southwestern Farming and Optimization Models of Transitions to Agriculture. In *Subsistence and Resource Use Strategies of Early Agricultural Communities in Southern Arizona*, edited by Michael W. Diehl, pp. 113–152. Anthropological Papers 34. Center for Desert Archaeology, Tucson.
- MacWilliams, A. C. 2001. Archaeology in Laguna Bustillos Basin, Chihuahua, Mexico. Unpublished Ph.D. dissertation, University of Arizona, Tucson.
- MacWilliams, A. C., Robert J. Hard, John R. Roney, Karen R. Adams, and William L. Merrill. 2006. *Investigaciones de los sitios de cultivo de maíz temprano en Chihuahua: Informe de la temporada de 2003*. Informe Técnico al Consejo de Arqueología, Instituto Nacional de Antropología e Historia. Mexico-North Research Network, Washington, D.C.
- MacWilliams, A. C., and Jane H. Kelley. 2004. A Ceramic Period Boundary in Central Chihuahua. In *Surveying the Archaeology of Northwest Mexico*, edited by Gillian E. Newell and Emiliano Gallaga, pp. 247–264. University of Utah Press, Salt Lake City.
- MacWilliams, A. C., John R. Roney, Robert J. Hard, Karen R. Adams, Natalia Martínez Tagüña, and William L. Merrill. 2009. *Investigaciones de los sitios tempranos de cultivo de maíz en Chihuahua, México, 2006*. Informe al Consejo de Arqueología, Instituto Nacional de Antropología e Historia. Mexico-North Research Network, Washington, D.C.
- Madsen, David B., and Steven R. Simms. 1998. The Fremont Complex: A Behavioral Perspective. *Journal of World Prehistory* 12:255–336.
- Marrs, Garland J. 1949. Problems Arising from the Surface Occurrence of Archaeological Material in Southeastern Chihuahua, Mexico. Unpublished Master's thesis, University of New Mexico, Albuquerque.
- Mason, J. Alden. 1971. Late Archaeological Sites in Durango, Mexico, from Chalchihuites to Zape. In *The North Mexican Frontier*, edited by Basil C. Hedrick, J. Charles Kelley, and Carroll L. Riley, pp. 130–143. Southern Illinois

- University Press, Carbondale. Originally published 1937, Philadelphia Anthropological Society, 25th Annual Studies, Philadelphia.
- Merrill, William L. 1988. *Rarámuri Souls: Knowledge and Social Process in Northern Mexico*. Smithsonian Institution Press, Washington, D.C.
- . 1991. La indoección religiosa en la Tarahumara colonial: Los informes de los visitantes Lizasoain y Aguirre al final de la época jesuita. In *Actas del Segundo Congreso Internacional de Historia Regional Comparada, 1990*, edited by Ricardo León García, pp. 283–302. Universidad Autónoma de Ciudad Juárez, Ciudad Juárez.
- . 1993. Conversion and Colonialism in Northern Mexico: The Tarahumara Response to the Jesuit Mission Program, 1601–1767. In *Conversion to Christianity: Historical and Anthropological Perspectives on a Great Transformation*, edited by Robert W. Hefner, pp. 129–163. University of California Press, Berkeley.
- . 2001. La identidad rarámuli: Una perspectiva histórica. In *La identidad y los pueblos étnicos en la Sierra Tarahumara*, edited by Claudia Molinari and Eugeni Porras, pp. 71–103. Instituto Nacional de Antropología e Historia and Congreso del Gobierno del Estado de Chihuahua, Mexico City.
- . 2012. The Historical Linguistics of Uto-Aztecan Agriculture. *Anthropological Linguistics* 54:203–260.
- . 2013. The Genetic Unity of Southern Uto-Aztecan. *Language Dynamics and Change* 3:68–104.
- Merrill, William L., Robert J. Hard, Jonathan B. Mabry, Gayle J. Fritz, Karen R. Adams, John R. Roney, and A. C. MacWilliams. 2009. The Diffusion of Maize to the Southwestern United States and Its Impact. *Proceedings of the National Academy of Sciences* 106:21019–21026.
- Merrill, William L., and Celia López González. 2007. Humans and Other Mammals in Prehispanic Chihuahua. In *Human and Faunal Relationships Reviewed: An Archaeozoological Approach*, edited by Eduardo Corona-M. and Joaquín Arroyo-Cabral, pp. 53–62. BAR International Series 1627. Archaeopress, Oxford.
- Metcalf, S. E. 2006. Late Quaternary Environments of the Northern Deserts and Central Transvolcanic Belt of Mexico. *Annals of the Missouri Botanical Garden* 93:258–273.
- Metcalf, S. E., A. Bimpson, A. J. Courtice, S. L. O'Hara, and D. M. Taylor. 1997. Climate Change at the Monsoon/Westerly Boundary in Northern Mexico. *Journal of Paleolimnology* 17:155–171.
- Miller, Wick R. 1983. Uto-Aztecan Languages. In *Southwest*, edited by Alfonso Ortiz, pp. 113–124. Handbook of North American Indians, Vol. 10, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.
- Nelson, Ben A. 1995. Complexity, Hierarchy, and Scale: A Controlled Comparison between Chaco Canyon, New Mexico, and La Quemada, Zacatecas. *American Antiquity* 60:597–618.
- . 1997. Chronology and Stratigraphy at La Quemada, Zacatecas, Mexico. *Journal of Field Archaeology* 24:85–109.

- . 2000. Aggregation, Warfare, and the Spread of the Mesoamerican Tradition. In *The Archaeology of Regional Interaction: Religion, Warfare, and Exchange across the American Southwest*, edited by Michele Hegmon, pp. 317–337. University Press of Colorado, Boulder.
- Nordt, Lee. 2003. Late Quaternary Fluvial Landscape Evolution in Desert Grasslands of Northern Chihuahua, Mexico. *Geological Society of American Bulletin* 115:596–606.
- Orcutt, Janet D. 1999. Demography, Settlement, and Architecture. In *The Bandelier Archaeological Survey*, edited by Robert P. Powers and Janet D. Orcutt, pp. 219–308. Professional Paper 57, Vol. 1. Intermountain Cultural Resource Management, Santa Fe.
- Ortega-Ramírez, José R., Alfonso Valiente-Banuet, Jaime Urrutia-Fucugauchi, Carlos A. Mortera-Gutiérrez, and Guillermo Alvarado-Valdez. 1998. Paleoclimatic Changes during the Late Pleistocene-Holocene in Laguna Babícora, near the Chihuahuan Desert, México. *Canadian Journal of Earth Sciences* 35:1168–1179.
- Pennington, Campbell W. 1963. *The Tarahumar of Mexico: Their Environment and Material Culture*. University of Utah Press, Salt Lake City.
- . 1969. *The Tepehuan of Chihuahua: Their Material Culture*. University of Utah Press, Salt Lake City.
- Phillips, David A., Jr. 1989. Prehistory of Chihuahua and Sonora, Mexico. *Journal of World Prehistory* 3:373–401.
- Pitcel, Todd. 2011. From Archaeology to Ideology in Northwest Mexico: Cerro de Moctezuma in the Casas Grandes Ritual Landscape. Unpublished Ph.D. dissertation, University of Arizona, Tucson.
- Raymond, Gerry R. 2001. La investigación de algunos sitios al sur de Chihuahua. In *Una investigación arqueológica de los sitios cerros con trincheras del arcaico tardío en Chihuahua, México: Informe al Consejo de Arqueología, Instituto Nacional de Antropología e Historia*, edited by Robert J. Hard, José E. Zapata, and John R. Roney. Translated by José E. Zapata and Lily Arely Aguilera. Special Report 27-S. Center for Archaeological Research, University of Texas at San Antonio, San Antonio.
- Raymond, Gerry R., John R. Roney, A. C. MacWilliams, Robert J. Hard, Karen R. Adams, and William L. Merrill. 2003. Looking for Early Maize between the Southwest and Mesoamerica: A Field Report from Southwest Chihuahua, Mexico. Paper presented at the 68th Annual Meeting of the Society for American Archaeology, Milwaukee, Wisconsin.
- Sanders, William T., Jeffrey R. Parsons, and Robert S. Santley. 1979. *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization*. Academic Press, New York.
- Seager, R., M. Ting, M. Davis, M. Cane, N. Naik, J. Nakamura, C. Li, E. Cook, and D. W. Stahle. 2009. Mexican Drought: An Observational Modeling and Tree Ring Study of Variability and Climate Change. *Atmósfera* 22:1–31.
- Stanislawski, Dan. 1947. Early Spanish Town Planning in the New World. *Geographical Review* 37:94–105.

- Stewart, Joe D., Jane H. Kelley, A. C. MacWilliams, and Paula J. Reimer. 2004. Archaeological Chronology in West-Central Chihuahua. In *Surveying the Archaeology of Northwest Mexico*, edited by Gillian E. Newell and Emiliano Galлага, pp. 205–245. University of Utah Press, Salt Lake City.
- Urrutia-Fucugauchi, Jaime, José R. Ortega-Ramírez, and R. Cruz-Gatica. 1997. Rock-Magnetic Study of Late Pleistocene-Holocene Sediments from the Babícora Lacustrine Basin, Chihuahua, Northern Mexico. *Geofísica Internacional* 36:77–86.
- Weigand, Phil C. 1975. Possible References to La Quemada in Huichol Mythology. *Ethnohistory* 22:15–20.
- Whalen, Michael E., and Paul E. Minnis. 2001. *Casas Grandes and Its Hinterland*. University of Arizona Press, Tucson.
- . 2009. *The Neighbors of Casas Grandes: Excavating Medio Period Communities of Northwest Chihuahua, Mexico*. University of Arizona Press, Tucson.
- Wilcox, David R., Phil C. Weigand, J. Scott Wood, and Jerry B. Howard. 2008. Ancient Cultural Interplay of the American Southwest in the Mexican Northwest. *Journal of the Southwest* 50:103–206.
- Winterhalder, Bruce, and Douglas J. Kennett. 2006. Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 1–21. University of California Press, Berkeley.
- Yale University Library, Social Science Research Services. 2004. Economic Growth Center Digital Library: Mexico Collection. Electronic document, <http://ssrs.yale.edu/egcdl/mxdl/index.jsp>, accessed June 15, 2012.
- Yeager, Timothy J. 1995. Encomienda or Slavery? The Spanish Crown's Choice of Labor Organization in Sixteenth-Century Spanish America. *Journal of Economic History* 55:842–859.

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*Understanding
the Past for
the Future*

Edited by
SCOTT E. INGRAM and
ROBERT C. HUNT



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